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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/637,107	08/08/2003	Gurtej S. Sandhu	3264.5US (92-0280.08/US)	5081

24247 7590 03/24/2004

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EXAMINER	
VOCKRODT, JEFF B	
ART UNIT	**PAPER NUMBER**
2822	

DATE MAILED: 03/24/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/637,107	SANDHU ET AL.	
	Examiner	Art Unit	
	Jeff Vockrodt	2822	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *05 November 2003*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-20* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-20* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *17 December 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

This office action is in response to the preliminary amendment filed on November 5, 2003. Claims 1-20 are pending.

Claim Objections

Claims 1-20 are objected to because of the following informalities: The claim language "predominantly no crystalline titanium therein" finds explicit support only as far back as application number 09/495,534, filed 31 January 2000, wherein the phrase "having virtually no crystalline titanium therein" was added to the originally filed claims. No explanation was given for how this subject matter may be supported by any earlier filed application in the chain of priority. Additionally, the claim language "predominantly no crystalline titanium therein" does not have antecedent basis in the present specification. Claims 1-20 are objected to under 37 CFR 1.75(d)(1), which requires that the claims "must conform to the invention as set forth in the remainder of the specification and the terms and phrases used in the claims must find clear support or antecedent basis in the description so that the meaning of the terms in the claim may be ascertainable by reference to the specification." Applicant is required to amend the specification to include antecedent basis for the claimed subject matter.

Claim 20 depends from claim 10, but merely recites the same subject matter as claim 10. Appropriate correction is required.

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. See *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970);and, *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 CFR 1.130(b).

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

Claims 1-20 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-10 of U.S. 6,632,736; claims 1-40 of U.S. 6,291,340; and claims 1-10 of U.S. 5,723,382 . Although the conflicting claims are not identical, they are not patentably distinct from each other. For instance the subject matter of claim 1 of '736 appears to fall entirely within the scope of the present claim 1.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 1-5, 11, and 15 are rejected under 35 U.S.C. 102(b) as being anticipated by WO 86/01640 ("Dean").

The following additional evidence has been considered in reaching the conclusion of inherent anticipation set forth herein: Eizenberg et al., TiCN: A new chemical vapor deposited contact barrier metallization for submicron devices, Appl. Phys. Lett. 65 (19), 7 November 1994, pp. 2416-18; Peng et al., Properties of CVD-W Overgrowth on PVD and MOCVD TiN Layers, IEEE, 5th International Conference Proceedings on Solid-State and Integrated Circuit

Technology, 1998, pp. 211-214; and Gordon and Katz (which were both cited by applicant in the specification).[1]

Dean teaches a titanium carbonitride diffusion barrier layer for an integrated circuit. The integrated circuit has a contact structure comprising: a silicon substrate (10), a dielectric (20) over a portion of the substrate (10); a contact opening exposing the substrate (10) in which a layer of titanium (25) is formed as an adhesion layer; a titanium carbonitride layer (24) is formed over the titanium adhesion layer (25); and aluminum (22) fills in a portion of the contact hole over the titanium carbonitride layer (24).

The claims require, "depositing a predominately amorphous titanium carbonitride film having predominately no definite crystalline structure and having predominately no crystalline titanium therein." Predominant (or predominate) means "being most frequent or common." Merriam-Webster's Collegiate Dictionary, 10th Ed. 1998. The claim term "predominately amorphous," given its broadest reasonable interpretation, denotes a film having crystallinity ranging from entirely amorphous to just less than 50% crystalline (or polycrystalline) in an amorphous matrix. The claim term "predominately no definite crystalline structure" adds nothing of substance to the "predominately amorphous" since amorphous means having no definite crystalline structure. The claim term "predominately no crystalline titanium therein" denotes a film having less than 50% crystalline titanium therein. In sum, the claim allows for substantial amounts (just less than 50%) of crystalline titanium and crystalline TiCN, while also covering entirely amorphous films. The examiner notes that many of the prior art references of record use methods that only detect the presence of a crystalline phase and do not measure the amount of amorphous material relative to the detected crystalline phase. Such analysis, if done by x-ray diffraction methods, would require a comparison of the width of the detected bands with

[1] The references cited in addition to Dean are only cited as evidence that Dean in fact inherently anticipates the claimed invention. See In re Donohue, 226 USPQ 619 (Fed. Cir. 1985) (finding anticipation based on more than one reference).

known standards to determine the percentage of total material that is of the crystalline phase relative to the amorphous phase.[2] Thus, the statements in the prior art regarding the presence of crystallinity or polycrystalline structure have little probative value for distinguishing the present claims which include films that have a substantial crystalline component (i.e., approaching 50%).

Dean teaches deposition of titanium carbonitride using a process that is the same or substantially the same in all relevant aspects to the claimed and disclosed process. The following table compares Dean with the disclosed invention:

	The invention	Dean
Precursor	TDMAT	TDMAT (page 4)
Temperature	200 - 600 C	325-375 C (page 4)
Pressure	<100 torr and <1 torr	0.04-0.1 torr (page 4)
Plasma	No	No
Composition as deposited	TiC_xN_y where y:x 5:1 to 10:1	TiC_xN_y where x=y=1 $0.8<x<1.2$; $0.8<y<1.2$

The amorphous nature of the deposited film appears to result from the large amount of carbon incorporated into the as-deposited film. This phenomena has been subsequently[3] documented in the literature: Eizenberg et al., TiCN: A new chemical vapor deposited contact barrier metallization for submicron devices, Appl. Phys. Lett. 65 (19), 7 November 1994, pp. 2417 ("The amorphous structure, which is not observed for reactively sputtered or CVD TiN, is attributed to the large amounts of C incorporated in our films") (footnotes omitted); Peng et al., Properties of CVD-W Overgrowth on PVD and MOCVD TiN Layers, IEEE, 5th International Conference Proceedings on Solid-State and Integrated Circuit Technology, 1998, pp. 211-214 (showing that a plasma treatment step reduced the carbon content and increased crystallinity of a TiCN film).

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[2] See US 6,383,467, Fig.1, col. 3, ll. 50-57 (amorphous content enlarges the band width of the diffraction peaks, but does not cause peaks to disappear altogether)--unless the film is entirely amorphous as shown in applicant's Fig. 2.

[3] Inherent anticipation does not require recognition of the missing descriptive matter at the time of invention. Schering Corp. v. Geneva Pharmaceuticals, Inc., 67 USPQ2d 1664, 1667 (Fed. Cir. 2003) ("At the outset, this court rejects the contention that inherent anticipation requires recognition in the prior art.").

Thus, the large amount of carbon deposited in the process of Dean and its similarity to the disclosed process suggests that the resultant titanium carbonitride film is an amorphous or at least a "predominately amorphous" layer.

The specification discusses and distinguishes Gordon (US 5,139,825) as resulting in a polycrystalline TiN layer. Gordon teaches six examples, the first of which is reportedly polycrystalline. The crystallinity of the other examples is not reported, which is significant because Gordon's example 5 is the example closest to Dean. Example 1 was run at 60°C and had less than 1% carbon, while example 5 was run at 400°C and had 8% carbon. The distinction between Gordon and the TiCN of the present invention, if there is a difference, appears to be due to the low temperature at which the film is deposited (60°C) in Gordon, which seems to allow less carbon incorporation. Dean is closer to the present invention than Gordon since Dean controls the temperature to within applicant's disclosed parameters and results in heavy carbon incorporation into the titanium carbonitride layer. The specification also discusses Katz, and states that Katz produces a crystalline film. Katz states, under section F on page 3673, that the as-deposited TiN_x layers (which have a high carbon content) resulted in "polycrystalline structure with very fine grain size" based on the data shown in Figs. 14-15. Katz deposits TiN_x directly onto a crystalline InP substrate as opposed to a CVD titanium layer. This is in contrast with the present invention and Dean, wherein each deposit TiCN directly onto a deposited titanium layer. Katz also uses a rapid thermal LPCVD process, whereas the present invention and Dean both use LPCVD. For the foregoing reasons, Dean is closer to the present invention than either of Gordon or Katz. Additionally, there is no indication in either Gordon or Katz that these films do not also have an amorphous phase, which means that they may in fact come within the claimed "predominately amorphous" film. In sum, the indirect comparative evidence in the specification is insufficient to show that Dean does not inherently produce a "predominantly amorphous" TiCN layer.

Based on the foregoing, it appears more likely than not that the missing descriptive matter of the claimed invention (i.e., "predominately amorphous") is an inherent property of Dean. Accordingly, the burden is on applicant to show that the titanium carbonitride film of Dean is not predominately amorphous. In re Spada, 911 F.2d 705, 15 USPQ2d 1655 (Fed. Cir. 1990); In re Fitzgerald, 619 F.2d 67, 205 USPQ 594 (CCPA 1980); Ex parte Anderson, 21 USPQ2d 1241,1251 (BdPatApp&Int 1991).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 7-8 and 17-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dean in view of U.S. 5,242,860 ("Nulman").

Dean is discussed above in relation to claims 1-5, 11, and 15. Dean does not teach reacting the titanium adhesion layer with the substrate to form a silicide before forming the titanium carbonitride barrier layer as required by claim 8.

Nulman discusses Ti/TiN adhesion barrier stacks in the context of interconnect contacts. Nulman discusses that it was conventional to anneal the titanium adhesion layer to form silicide (col.1, ll. 29-37) and then deposit a layer of TiN over the annealed film to provide a sufficiently thick barrier layer (col. 1, ll. 49-54). Nulman teaches that this method "results in satisfactory formation of a titanium silicide contact layer and a titanium nitride barrier layer over the silicide" (col. 1, ll. 55-57).

It would have been obvious to one of ordinary skill in the art to anneal the titanium adhesion layer of Dean to form a silicide layer prior to depositing the titanium carbonitride layer

since the foregoing process will result in a satisfactory titanium silicide contact layer underneath the barrier layer as taught by Nulman.

Claims 6-7 and 16-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dean in view of U.S. 4,960,732 ("Dixit").

Dean is discussed above in relation to claims 1-5, 11, and 15. Dean does not teach a plug comprising doped polysilicon as required by claims 6 and 16.

Dixit teaches a contact plug and interconnect employing a barrier lining and a backfilled conductor material. Dixit teaches that plugs are useful in overcoming problems with depositing aluminum in tight (high aspect ratio) vias (col. 1, ll. 35-50). Dixit teaches tungsten and in-situ doped polysilicon as being useful plug materials (col. 5, ll. 30-45). Dixit specifically teaches an in-situ doped polysilicon plug process, which is useful in achieving a uniform dopant distribution (col. 2, ll. 10-15). Dean further teaches that it is desirable to anneal a Ti/TiN layer to form silicide (col. 7, ll. 9-11).

It would have been obvious to one of ordinary skill in the art at the time of the invention to use an in-situ doped polysilicon or tungsten plug in the process of Dean. One of ordinary skill in the art would have been motivated by Dixit's teaching that plugs allow formation of high aspect ratio contacts and that in-situ doped polysilicon overcomes problems with dopant uniformity.

Claims 9-10, 12-14 and 19-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dean in view of U.S. 4,998,151 ("Korman").

Dean is discussed above in relation to claims 1-5, 11, and 15. Dean does not teach subjecting the contact structure to RTA in a nitrogen, hydrogen, or noble gas environment as required by claims 10 and 20.

Korman teaches a process of forming a TiSix layer in which rapid thermal annealing (RTA) is performed for 20 seconds in a nitrogen ambient (col. 9, ll. 2-8). Korman teaches that RTA can accomplish in 20 seconds, what takes 40 minutes without rapid thermal annealing.

It would have been obvious to one of ordinary skill in the art at the time of the invention to use the nitrogen RTA silicidation process in the process of Dean in order to form a silicide layer in a shorter period of time as taught by Korman.

Claims 12-14 require subject matter that is met by Dean as discussed above.

Claims 5 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dean in view of Eizenberg et al., TiCN: A new chemical vapor deposited contact barrier metallization for submicron devices, Appl. Phys. Lett. 65 (19), 7 November 1994, pp. 2416-18 ("Eizenberg").

The subject matter of claims 5 and 15 have an effective filing date of July 31, 1995, which is the filing date of application 08/509,107. The copper and nickel limitations of claims 5 and 15 lack support in any application filed prior to 08/509,107 in the chain of priority. Eizenberg was published in November of 1994 and is thus prior art against claims 5 and 15 under §102(a). Dean is discussed above in relation to claims 1-5, 11, and 15. Dean does not expressly disclose a "predominately amorphous" TiCN layer, but does disclose aluminum metal. To the extent that applicant may overcome its burden in showing that Dean does not meet the "predominantly amorphous" limitation, Eizenberg is cited. Eizenberg teaches that TiCN layers having an amorphous structure are desirable for making barrier layers having excellent step coverage and barrier properties (entire reference). It would have been obvious to one of ordinary skill in the art at the time of the invention to produce an amorphous TiCN layer in the process of Dean in order to improve the step coverage and barrier properties of the barrier layer as taught by Eizenberg.

Claims 8 and 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dean and Eizenberg as applied to claims 5 and 15 above, further in view of Nulman.

The subject matter of claims 8 and 18 have an effective filing date of July 31, 1995, which is the filing date of application 08/509,107. The limitation of claims 8 and 18 that reacting occur prior to depositing the barrier layer lacks support in any application filed prior to 08/509,107 in the chain of priority. Dean and Eizenberg are discussed above in relation to claims 5 and 15. Dean does not teach reacting the titanium adhesion layer with the substrate to form a silicide before forming the titanium carbonitride barrier layer as required by claim 8.

Nulman discusses Ti/TiN adhesion barrier stacks in the contacts of interconnect contacts. Nulman discusses that it was conventional to anneal the titanium adhesion layer to form silicide (col.1, ll. 29-37) and then deposit a layer of TiN over the annealed film to provide a sufficiently thick barrier layer (col. 1, ll. 49-54). Nulman teaches that this method "results in satisfactory formation of a titanium silicide contact layer and a titanium nitride barrier layer over the silicide" (col. 1, ll. 55-57).

It would have been obvious to one of ordinary skill in the art to anneal the titanium adhesion layer of Dean and Eizenberg to form a silicide layer prior to depositing the titanium carbonitride layer since the foregoing process will result in a satisfactory titanium silicide contact layer underneath the barrier layer as taught by Nulman.

Claims 6 and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dean and Eizenberg as applied to claims 5 and 15 above, further in view of Dixit.

The subject matter of claims 6 and 16 have an effective filing date of July 31, 1995, which is the filing date of application 08/509,107. The doped polycrystalline silicon limitation of claims 6 and 16 lacks support in any application filed prior to 08/509,107 in the chain of priority. Dean and Eizenberg are discussed above in relation to claims 5 and 15. Dean does not teach a plug comprising doped polysilicon as required by claims 6 and 16.

Dixit teaches contact plug and interconnects employing a barrier lining and a backfilled conductor material. Dixit teaches that plugs are useful in overcoming problems with depositing aluminum in tight (high aspect ratio) vias (col. 1, ll. 35-50). Dixit teaches tungsten and in-situ doped polysilicon as being useful plug materials (col. 5, ll. 30-45). Dixit specifically teaches an in-situ doped polysilicon plug process, which is useful in achieving a uniform dopant distribution (col. 2, ll. 10-15). Dean further teaches that it is desirable to anneal a Ti/TiN layer to form silicide (col. 7, ll. 9-11).

It would have been obvious to one of ordinary skill in the art at the time of the invention to use an in-situ doped polysilicon or tungsten plug in the process of Dean and Eizenberg. One of ordinary skill in the art would have been motivated by Dixit's teaching that plugs allow formation of high aspect ratio contacts and that in-situ doped polysilicon overcomes problems with dopant uniformity.

Conclusion

Any inquiry concerning communications from the examiner should be directed to Jeff Vockrodt at (571) 272-1848. The examiner can be reached on weekdays from 9:30 am to 5:00 pm EST. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Amir Zarabian, can be reached at (571) 272-1852.

The fax number for official correspondence is (703) 872-9306. Unofficial communications to the examiner may be faxed to (571) 273-1848. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist at (703) 308-0956.

March 7, 2004
J. Vockrodt

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